Fisheries and Oceans Science | Pêches et Océans Sciences

CSAS | **SCÉS**

Canadian Stock Assessment Secretariat | **Secrétariat canadien pour l'évaluation des stocks**

Research Document 2000/174 | **Document de recherche 2000/174**

Not to be cited without permission of the authors [1] | Ne pas citer sans autorisation des auteurs [1]

Review of the 1999 Return of Barkley Sound Sockeye Salmon and Forecasts for 2000

K. Hyatt, W. Luedke, J. Till, P. Rankin, and D. Lewis

Fisheries and Oceans Canada
Stock Assessment Division
Pacific Biological Station
Nanaimo, B.C. V9R 5K6

[1] This series documents the scientific basis for the evaluation of fisheries resources in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

[1] La présente série documente les bases scientifiques des évaluations des ressources halieutiques du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

Research documents are produced in the official language in which they are provided to the Secretariat.

Les documents de recherche sont publiés dans la langue officielle utilisée dans le manuscrit envoyé au Secrétariat.

This document is available on the Internet at: http://www.dfo-mpo.gc.ca/csas/

Ce document est disponible sur l'Internet à:

ISSN 1480-4883
Ottawa, 2000

Canada

Abstract

Recent year returns of Barkley Sound sockeye have been gradually increasing from a low of only 200,000 fish in 1995 to 380,000 in 1996, 465,000 in 1997 and 660,000 in 1998 (Figure 2). Although moderate, recent increases were anticipated by two independent forecasting procedures first developed in 1987 and applied annually since 1988 to predict return variations of Barkley Sound and West Coast Vancouver Island (WCVI) sockeye. Given the gradual recovery of the stock in recent years, aboriginal, recreational and small commercial fisheries were correctly anticipated in 1997 1998 and 1999. Recent year stock increases represent a continuation of a pattern of predictable variations in ocean climate states that have lead to repeated "crashes" (1978, 1985-86, 1989-90, 1994-95) followed within 1-3 years by recoveries (1979-81, 1987-88, 1991-93, 1996-98) of WCVI sockeye returns. The surplus for commercial catch in recent years is directly attributable to the combined effects of: (i) a shift of conditions in the marine environment that supported near average survival of sockeye smolts migrating seaward between 1994 and 1997 and (ii) management to protect escapement as a basis for increases in future year returns.

Over the past 12 years, four independent techniques have been tested for their utility in generating reliable pre-season forecasts of Barkley Sound sockeye returns for harvest managers. The four techniques are known as the Salinity Survival Method (SSM), the Survival Stanza Method (SStM), the Sibling Age Class Method (SACM), and the Salmonid Enhancement Program Biostandard Method (SEPB). Updates on the performance of three of these techniques in 1999 are as follows:

(1) The SStM forecast exhibits the best overall performance with a Mean Absolute Percent Error (MAPE) value of approximately 28 % over the most recent 12 years of forecasting (Table 5.). Further, SStM forecasts account for the majority of variations in returns if the extreme observation associated with the 1991 return year is omitted from the analysis (returns = 1.17 SStM forecasts - 66.35, $r^2 = 0.78$, $P<0.01$).

(2) The SSM forecast exhibits the next best performance with a MAPE value of 35 % over the most recent 12 years of forecasting. SSM forecasts also exhibit a statistically significant association with returns if the 1991 return year is omitted from the analysis (returns = 0.83 SSM forecasts + 35.28, $r^2 = 0.77$, $P<0.01$).

(3) SEPB forecasts have performed well over some return intervals but not others. During the 1988-1998 testing interval SEPB forecasts exhibited a substantially higher MAPE value (54 %) than that displayed by both SSM and SStM forecasts (28-34 %). Large magnitude deviations between SEPB forecasts and actual returns tend to occur in consecutive years thus seriously eroding the confidence of harvest managers as well as fishers in their utility.

Different models provide highly divergent forecast alternatives for returns of Barkley Sound sockeye in the year 2000. Midpoint forecast estimates range from a low of 532,000 to a high of 1,900,000 Barkley Sound sockeye. Comparative performance of the various forecast options and supplementary observations of coho marine survival variations as a leading indicator suggest that sockeye returns in the year 2000 are likely to be closer to the lower than the upper end of this range. Given, DFO's recent pursuit of a more risk averse approach to management we recommend initial adoption of the SStM forecast range of 485,000 (75 % probability) to 714,000 (25 % probability) sockeye as the preferred, pre-season forecast for the year 2000 (Table 14.).

Résumé

La remonté du saumon rouge de la baie Barkley a connue une hausse graduelle au cours des dernières années, passant de seulement 200 000 poissons en 1995 à 380 000 en 1996, 465 000 en 1997 et 660 000 en 1998. Bien que modérée, cette augmentation récente était anticipée, grâce à deux méthodes de prévision indépendantes mises au point en 1987 et appliquées annuellement depuis 1988 pour prédire les variations des remontés du saumon rouge de la baie Barkley et de la côte ouest de l'île de Vancouver (COIV). Le rétablissement graduel du stock au cours des dernières années indique que les pêches autochtones récréatives et commerciales ont été correctement anticipées en 1997, 1998 et 1999. L'accroissement de l'abondance suit un cycle régulier du climat océanique qui engendre une succession d'effondrements (1978, 1985-1986, 1989-1990, 1994-1995) et de rétablissements (1979-1981, 1987-1988, 1991-1993, 1996-1998) des remontés de saumon rouge de la COIV, suivant un interval de un à trois ans. Les excédents pouvant être récoltés par les pêcheurs commerciaux dans les dernières années sont directement attribuables aux effets combinés des éléments suivants : (i) un changement des conditions dans le milieu marin, qui a assuré une survie presque moyenne des smolts de saumon rouge migrant vers la mer entre 1994 et 1997 et (ii) les mesures de gestion visant à protéger l'échappée en vue d'assurer des remontés futures plus abondantes.

Au cours des 12 dernières années, nous avons vérifié l'utilité de quatre méthodes indépendantes pour ce qui est de fournir aux gestionnaires des pêches des prévisions pré-saison fiables des remontés de saumon rouge de la baie Barkley. Ces méthodes sont la méthode de survie à la salinité (SSM), la méthode des couplets de survie (SStM), la méthode des classes d'âge de la fratrie (SACM), et la méthode biologique normalisée du Programme de mise en valeur des salmonidés (SEPB). La performance de trois de ces méthodes pour la saison 1999 est décrite ci-bas.

(1) La prévision issue de la SStM affiche la meilleure performance générale, le pourcentage de l'erreur absolue moyenne (PEAM) des prévisions pour les 12 dernières années se chiffrant à environ 28 %. Ces prévisions représentent en outre la plus grande partie des variations des remontés lorsque la valeur exceptionnelle liée à la remonté de 1991 est omise de l'analyse (remontés = 1,17 prévisions SStM - 66,35, $r^2 = 0,78$, $P < 0,01$).

(2) La prévision issue de la SSM affiche la deuxième meilleure performance, le PEAM des prévisions pour les 12 dernières années se chiffrant à 35 %. Ces prévisions montrent en outre une association significative lorsque la remonté de 1991 est omise de l'analyse (remontés = 0,83 prévisions SSM + 35,28, $r^2 = 0,77$, $P < 0,01$).

(3) Les prévisions issues de la SEPB affichent une bonne performance pour certains intervalles de remontés, seulement. Pour l'intervalle expérimental 1988-1998, elles affichent un PEAM nettement plus élevé (54 %) que ceux des prévisions SSM et SStM (28-34 %). De grands écarts entre les prévisions SEPB et les remontés réelles ont tendance à se produire tous les ans, ce qui réduit fortement la confiance des gestionnaires des pêches ainsi que des pêcheurs quant à leur utilité.

D'autres modèles donnent des prévisions des remontés de saumon rouge de la baie Barkley pour 2000 différant considérablement. Les estimations médianes varient d'un creux de 532 000 poissons à un pic de 1 900 000. La performance comparative des diverses méthodes de prévision et des observations additionnelles de la variation de la survie en mer du coho à titre d'indicateur principal portent à croire que les remontés de saumon rouge en 2000 se situeront probablement plus proches du bas que du haut de cette étendue. Étant donné la récente approche de gestion du MPO, qui vise à minimiser les risques, nous recommandons l'utilisation de la méthode SStM pour 2000, la prévision pré-saison s'étalant entre 485 000 (probabilité à 75 %) et 714 000 (probabilité à 25 %) saumons rouges.

Introduction:

Detailed summaries of stock status, stock assessment methodologies and forecasting procedures for Barkley Sound sockeye have been presented as PSARC working papers subjected to peer review on several occasions in recent years (Hyatt 1986, Hyatt and Steer 1988; Hyatt and Heizer 1989; Hyatt et. al. 1994, Hyatt and Luedke 1995, 1996). The purpose of the present document is to provide a brief update focused on: (i) an appraisal of the performance of the 1999 forecasts relative to estimates of actual returns, (ii) provision of return year 2000 forecasts and (iii) commentary on the implications of (i) and (ii) for year 2000 harvest planning. Readers interested in detailed descriptions of stock histories, data sources, field survey methods or development of analytical procedures are encouraged to consult earlier papers cited above.

Here briefly, three Barkley Sound sockeye stocks (Great Central, Sproat and Henderson) are managed within a set of mixed-stock, mixed-gear fisheries operating in Area 23 (Steer et. al. 1986; Hyatt and Steer 1987) on the west coast of Vancouver Island (Figure 1). Great Central and Sproat Lake sockeye originate from the Somass River watershed at the head of Alberni Inlet. Henderson Lake supports the third sockeye stock and is located at the seaward boundary of Alberni Inlet. The migration of Somass River sockeye stocks into Alberni Inlet begins about June 1 and continues until mid August with a peak about July 10. Migration into the river may be delayed by environmental conditions (Steer and Hyatt 1987), causing the timing of the tail of the run into the Somass River to extend into October. The return timing of Henderson Lake sockeye to Alberni Inlet is currently assumed to be about three weeks later than the Somass stocks, although timing of entry into the Henderson River and the Clemens Creek spawning grounds is more variable and dependent on water flows. Spawning occurs on beaches and in tributaries of the lakes in late October to late November.

The long term average target escapement is 350,000 for the Somass system, including 200,000 for Great Central Lake and 150,000 for Sproat Lake. The target escapement for Henderson Lake is 50,000 sockeye. The escapement into Great Central Lake and Sproat Lake has averaged 364,000 sockeye during the period 1979 to 1998 with a range from a low of 167,000 in 1995 to a high of 648,000 in 1991 (Table 1). The average escapement into Henderson Lake and Clemens Creek during the same interval was 34,549 ranging from a low of 3000 in 1995 to a high of 120,000 in 1993. The average annual total return of Barkley Sound sockeye during the period 1979 to 1998 was 829,000 with a range of 200,000 to 1,800,000 (Tables 1 and 2).

Barkley Sound sockeye stocks support First Nations food, social, and ceremonial needs, First Nations "pilot sales" fisheries, sport fishing, and commercial fisheries. The average annual catch was approximately 430,000 sockeye during the period 1979 through 1998. Since 1995, Somass River sockeye have been managed based on a variable harvest rate increasing with abundance from 10% at run sizes above 200,000 to a maximum of 67% at 1.8 million (Table 3). No fisheries, other than assessment requirements, are permitted below 200,000 sockeye. The management of the fisheries targeting these stocks is structured to avoid Henderson Lake sockeye when the forecast of their returns is below the target escapement.

Review of 1999 Returns of Somass River Sockeye:

Total returns of approximately 509,000 sockeye to Barkley Sound in 1999 achieved 61 % of the most recent twenty year average (829,000) and maintained a mid-range value for a stock that has fluctuated between recent year extremes of less than 200,000 to more than 1.8 million sockeye (in 1995 and 1991 respectively, Figure 2). A total catch of 117,000 sockeye was taken in 1999 divided among: food and pilot sales by Indian Bands (40,820 sockeye), commercial gillnet (55,098 sockeye), commercial trollers (8,819 sockeye), recreational fisheries (7,870 sockeye) and test fishery catch (4,445 sockeye). Total catch in 1999 was noticeably lower than that achieved in 1997 or 1998 and represents only 27 % of the most recent twenty year average (1979-98, Table 2). The decline in recreational catch between 1998 and 1999 (from 55,421 to just 7,870 sockeye) was especially steep but this may be attributed to high flows and low temperatures in the Somass River which encouraged rapid migration of sockeye through Alberni Inlet to their lakes of origin. Overall, the 1999 stock performance represents a pause relative to several recent years of modest stock rebuilding observed between 1995 and 1998 (Figure 2.).

Barkley Sound escapements to October totalled 392,353 sockeye comprised of 172,852 Sproat Lake and 215,089 Great Central Lake fish. Peak live plus dead counts over several surveys indicate that only 4,412 sockeye reached the Clemens Creek spawning grounds at Henderson Lake in 1999 (Hyatt et. al. unpublished data and Table 1).

1999 Forecast Performance:

Three independent techniques were used to generate 1999 return forecasts for Barkley Sound sockeye (Hyatt and Luedke S99-8). These were:

(1) Survival stanza method (SStM): the SStM forecast was for returns of 332,305 sockeye to Barkley Sound in 1999.

(2) Sea survival/salinity method (SSM): the SSM forecast was for returns of 575,129 sockeye to Barkley Sound in 1999.

(3) Salmon Enhancement Biostandard Method (SEPB): the SEPB forecast was for returns of 664,612 sockeye to Barkley Sound in 1999.

Review of 11 years of forecast results (Hyatt and Luedke, S99-8) indicated the SStM and SSM forecasts exhibited lower mean percent deviations from observed than the SEPB forecast and explained significantly more of the variation in annual returns than other techniques (Tables 4 & 5). SStM and SSM forecasts (332,000 and 575,000 sockeye respectively) indicated that 1999 returns would be of similar magnitude to those observed in 1997 and 1998 but well below the 20 year average. Given the comparative performance of the various forecast options, along with DFO's recent pursuit of a more risk averse approach to management, PSARC recommended an SStM forecast range of 302,000 (75 % probability) to 433,000 (25 % probability) sockeye as the preferred, pre-season forecast for 1999.

Approximately 509,000 sockeye returned to Barkley Sound in 1999 such that observed returns fell within 13 %, 35 % and 31 % of the SSM, SStM and SEPB forecasts respectively (Table 4). Several in-season indicators (sport and native CPUE's, Somass cumulative escapement) suggested early on that 1999 returns favoured the high end of the pre-season forecast range (302 to 433 thousand sockeye at 75 % and 25 % probability levels under the SStM forecast) and supported management actions for openings of Native, recreational and commercial gillnet fishing early in the season. In-season indicators for both catch and escapement continued to suggest that the upper end of the SStM forecast range would be met or exceeded and that the SSM forecast midpoint of 575,129 sockeye might be more applicable to the 1999 return. The absence of any prolonged migration delay by sockeye in Alberni Inlet prior to their upriver migration during the 1999 return year contributed to timely escapement enumeration at upriver sites. This produced an especially close correspondence between in-season forecasts based on a simple run timing model (Steer and Hyatt 1987) and post season stock totals observed in 1999 (Table 6).

Return Year 2000 Forecasts:

The same forecast techniques (SStM, SSM and SEPB: methodological details in S95-13, Hyatt and Luedke 1995) applied in recent years (1987-1999) have been employed to generate return forecasts for 2000.

(1) Survival stanza method (SStM): Adult sockeye returns to Barkley Sound in 1999 will be derived from a 1997 cohort of 10.35 million smolts, returning as 1.3's and 2.2's, and a larger 1998 cohort of 28.21 million smolts, returning as 1.2's (Table 7). Marine temperature conditions at Amphitrite Point during the period of seaward migration (March-May) by smolts exhibited values relative to the 53 year mean of 9.38 ^{o}C that were well above average in both 1997 (10.1 ^{o}C) and 1998 (10.43). These observations suggest that both smolt cohorts generating the majority of year 2000 returns should be assigned the lower marine survival rate (2.5 %) permitted under SStM forecasts (Hyatt and Luedke S95-13). Application of this rate to the 1997 and 1998 smolt cohorts produces an SStM forecast of 532,099 sockeye of all age classes in 2000 (Tables 7 & 8).

(2) Sea survival/salinity method (SSM): Given the magnitude of smolt releases and salinity conditions (Table 9) that suggest a return to high marine survival rates in both 1997 and 1998, the SSM forecast is for returns of 1,900,000 sockeye to Barkley Sound in the year 2000. (Tables 10 & 11).

(3) Salmon enhancement biostandard method (SEPB): Given cohorts of 10.35 million smolts (returning as 1.3's and 2.2's) and 28.21 million smolts (returning as 1.2's) in 1997 and 1998 respectively, application of a 4.5 % SEP biostandard survival rate produces a SEPB forecast of 945,767 sockeye to Barkley Sound in the year 2000 (Tables 12 & 13).

Discussion:

Over the past 12 years, four independent techniques have been tested for their utility in generating reliable pre-season forecasts of Barkley Sound sockeye returns for harvest managers. The four techniques are known as the Salinity Survival Method (SSM), the Survival Stanza Method (SStM), the Sibling Age Class Method (SACM), and the Salmonid Enhancement Program Biostandard Method (SEPB). Updates on the performance of three of these techniques in 1999 are as follows:

(1) The SStm forecast exhibits the best overall performance with a Mean Absolute Percent Error (MAPE) value of approximately 28 % over the most recent 12 years of forecasting (Table 5). Further, SStM forecasts account for the majority of variations in returns if the extreme observation associated with the 1991 return year is omitted from the analysis (returns = 1.17 SStM forecasts - 66.35, $r^2 = 0.78$, $P<0.01$).

(2) The SSM forecast exhibits the next best performance with a MAPE value of 34 % over the most recent 12 years of forecasting. SSM forecasts also exhibit a statistically significant association with returns if the 1991 return year is omitted from the analysis (returns = 0.83 SSM forecasts + 35.28, $r^2 = 0.77$, $P<0.01$).

(3) SEPB forecasts have performed well over some return intervals but not others. During the 1988-1999 testing interval SEPB forecasts exhibited a substantially higher MAPE value (54 %) than that displayed by both SSM and SStM forecasts (28-34 %). Large magnitude deviations between SEPB forecasts and actual returns tend to occur in consecutive years (Table 5) which seriously erodes the confidence of harvest managers as well as fishers in their utility even though SEPB forecasts exhibit a significant association with actual returns (Table 5., returns = 1.42 SEPB forecasts – 495.8 , $r^2 = 0.68$, $P<0.01$).

All three forecast alternatives indicate that year 2000 returns for Barkley Sound sockeye will increase relative to returns observed over the past 5 years. However, the magnitude of the predicted return ranges between a modest increase under the SStM forecast, a substantial increase under the SEPB forecast or a near record breaking increase if one accepts the SSM forecast (Table 14 and Figure 2). Comparative performance of the various forecast options, along with DFO's recent pursuit of a more risk averse approach to management has led the Salmon Subcommittee of PSARC to commonly recommend the SStM forecast bounded by the 25 to 75 % probability range that the actual run size will exceed the SStM forecast. However, in most years, the divergence in expected returns under alternative models has been much smaller than that predicted by the SStM and SSM forecast alternatives for the year 2000.

The general level of agreement normally observed between forecasts based on either SStM or SSM models is largely due to the fact that outputs from both models are driven by changes in measures of either ocean temperature (SStM) or ocean salinity (SSM) conditions that usually covary. However, during the 1998 sea entry year increases in coastal zone salinity that anticipate increases in marine survival of sockeye under the SSM were not accompanied by a large enough decline in ocean temperatures to drop below the long term mean which is a condition of the SStM model to assume an increase in the sockeye smolt-to-adult survival rate

(Hyatt and Luedke 1995). Thus, whether to accept the risk averse SStM mid-point forecast of 532,000 (25 to 75 % probability range of 485,000 to 714,000) or to anticipate a much larger, mid-point forecast of 1,900,000 under the SSM (25 to 75 % probability range of 1,185,000 to 2,146,000) is an issue for year 2000 returns. In the absence of additional information, there appears to be no compelling basis on which to favour either the SStM or the SSM forecast alternatives for the year 2000. One of us (K. Hyatt unpublished analysis) has recently identified a relationship between marine survival variations for Robertson Creek coho and annual return deviations exhibited by Barkley Sound sockeye. These results are introduced here in preliminary form because of their potential relevance to selection of a return forecast for sockeye in the year 2000.

Preliminary Coho Leading Indicator (CLI) Observations:

The CLI is based on the observation that changes in marine survival variations for both juvenile sockeye and coho migrating through Barkley Sound and up the west coast of Vancouver Island may be expected to covary. This is because both species face similar changes in physical and biological conditions (changes in abundance of planktonic prey or predators) at sea entry in a given year. Further, because virtually all Robertson Creek coho return as adults a year in advance of the sockeye they migrated seaward with, empirical observations of smolt-to-adult survival levels for a given brood year of coho are available one year in advance of those of sockeye originating from the same brood year. Accordingly, coho survival values observed in year n may anticipate survival values or return deviations to be exhibited by sockeye in year n+1.

Analysis of recent year observations of sockeye smolt-to-adult survival variations are still incomplete. However, a preliminary examination of whether coho survival variations may serve as a leading indicator of the following year's sockeye returns is possible based on a comparison of year n deviations of Robertson Creek coho from their 23 year mean smolt-to-adult survival value versus year n+1 deviations by sockeye from their 24 year mean of total returns (Table 15). Relationships based on analysis of observations from the full period of record (the CLI based on the 24 brood years from 1972 to 1995) as well as the latter half of this interval (the CLI based on 12 brood years from 1984 to 1995) were both highly significant (Table 16). Thus, the coho leading-indicator of sockeye appears to have some utility. Smolt-to-adult survival of 1996 Robertson Creek brood year coho was 2.1 % (Diana Dobson, pers. comm.). Consequently, values for the CLI_{24} (611,800) and CLI_{12} (490,648) observations (Table 16) constitute supplementary evidence that returns are likely to be closer to the SStM than the SSM sockeye forecast during the year 2000.

Beginning in 1995, DFO established an "in-season" management benchmark of escapement of 200,000 Somass sockeye to satisfy biological conservation objectives (Appendix, Attachment 1, Tousignant to Eidsvik, Oct.4, 1995 in Hyatt and Luedke 1995). Accordingly, fisheries managers are committed to eliminating or avoiding exploitation of Somass sockeye when either pre-season or in-season abundance indicators suggest stock sizes of 200,000 or less. Although various forecasts identified here diverge dramatically (i.e. range of predicted midpoint values 532,000 – 1,900,000), returns of sockeye to Barkley Sound in the year 2000 have a greater than 90 % probability of being above the 200,000 escapement benchmark under

all forecast alternatives. Given the variable harvest rate strategy adopted in 1996 (Anonymous 1996), harvest projections under even a precautionary SStM forecast will range from a total allowable catch (TAC) of more than 124,000 sockeye given an SStM return of 485,000 (75 % probability) to a TAC of 313,000 given an SStM return of 714,000 (25 % probability).

Recommendations:

(1) We recommend an SStM forecast of 485,000-714,000 sockeye as a conservative, risk averse range of expected returns to Barkley Sound in 2000. Although the SSM forecast suggests the possibility of a record return (i.e. a mid-point forecast of 1.9 million sockeye) supplementary observations based on the identification of a significant association between coho marine survival variations and sockeye return deviations suggests the lower SStM forecast range above to be more likely.

(2) Given the strong divergence of returns predicted on the basis of either the SStM or SSM forecasts, we recommend careful review of return indicators to verify their relative merits as data accumulate in-season.

References:

Anonymous. 1996. Overview of Alberni Inlet sockeye management: 1996 pre-season planning for Alberni Inlet sockeye. Unpublished document. Department of Fishereis and Oceans, South Coast Division, Stevenson Point Road, Nanaimo, B.C. 9 p.

Hyatt, K. D. and J. G. Stockner. 1985. Responses of sockeye salmon (Oncorhynchus nerka) to fertilization of British Columbia coastal lakes. Can. J. Fish. Aquat. Sci. 42: 320-331.

Hyatt, K. D. 1986. Advice on Barkley Sound sockeye. PSARC Advisory Document S86-6: 11p.

Hyatt, K. D. and G. J. Steer. 1987. Barkley Sound sockeye salmon (Oncorhynchus nerka): Evidence for over a century of successful stock development, fisheries management, research, and enhancement efforts. Can. Spec. Publ. Fish. Aquat. Sci. 96: 435-457.

Hyatt, K. D. and G. J. Steer. 1988. Stock status and 1988 forecasts of Barkley Sound sockeye. PSARC Working Paper S88-2.

Hyatt, K. D. and S. Heizer. 1989. Stock status and 1990 forecasts of Barkley Sound sockeye. PSARC Annual Update S90-19.

Hyatt, K. D., W. Luedke, D. P. Rankin, and L. Gordon. 1994. Review of 1988-1994 forecast performance, stock status and 1995 forecasts of Barkley Sound sockeye. PSARC Working Paper S94-21. 18 p. plus appendices.

Hyatt, K. D.and W. Luedke.1995. Review of 1988-1995 forecast performance, stock status and 1996 forecasts of Barkley Sound sockeye. PSARC Working Paper S95-13. 57 p.

Hyatt, K. D. and W. Luedke. 1996. An update on 1996 stock status and 1997 forecasts of Barkley Sound sockeye. PSARC Working Paper S96-21. 38 p.

Hyatt, K. D. and W. Luedke. 1998. An update on 1997 stock status and 1998 forecasts of Barkley Sound sockeye. PSARC Working Paper S98-4. 33 p.

Hyatt, K.D. and W. Luedke. 1999. An update on 1998 stock status and 1999 forecasts of Barkley Sound Sockeye. PSARC Working Paper S99-08. 24 p.

Rice, J. R., L. Richards, R. Kadowaki, D. Welch, M. Stocker, B. Turris, G. A. McFarlane, F. Dickson, and D. Ware (eds.).1996. Pacific Stock Assessment Review Committee (PSARC) Annual Report for 1995.

Steer, G. J., N. B. F. Cousens, H. Stiff and K. D. Hyatt. 1986. An analysis of gear selectivity and sources of bias in estimates of age and stock composition of the 1980-1984 Barkley Sound sockeye salmon (Oncorhynchus nerka) catch. Can. Tech. Rep. Fish. Aquat. Sci. No 1445. 77 p.

Steer, G. J. and K. D. Hyatt. 1987. Use of a run timing model to provide in-season estimates of sockeye salmon (Oncorhynchus nerka) returns to Barkley Sound, 1985. Can. Tech. Rep. Fish. Aquat. Sci. No. 1557: 39 p.

Table 1. Barkley Sound sockeye escapement summary

Year	Total	Hen.	GCL	Sproat
1977	297800	4800	212200	80800
1978	158900	7000	114400	37500
1979	360441	20000	263995	76446
1980	318736	20760	159597	138379
1981	430191	40354	262287	127550
1982	470261	56065	172269	241927
1983	644987	44987	350000	250000
1984	267524	45122	133306	89096
1985	299719	25000	127758	146961
1986	316361	5000	118420	192941
1987	435969	29000	255153	151816
1988	460265	30000	194848	235417
1989	425401	38000	219414	167987
1990	323910	35000	176850	112060
1991	698470	50000	437172	211298
1992	429416	27000	191154	211262
1993	540809	120000	238094	182715
1994	265346	15138	106706	143502
1995	169293	3000	63893	102400
1996	325123	21000	120173	183950
1997	321036	21000	174063	125973
1998	452921	30000	236043	186878
1999	392353	4412	215089	172852

Table 2. Barkley Sound catch

Year	Total	Exploitation Rate	% of Total by Stock Hend.	GCL	Sprt.
1977	1101211	0.78			
1978	185100	0.54			
1979	727725	0.67			
1980	642800	0.67	4.4	52.7	42.8
1981	919000	0.68	2.9	59.1	38.1
1982	410000	0.47	2.1		
1983	860000	0.57	4.6	55.3	40.1
1984	914602	0.77	5.2	59.7	35.2
1985	367000	0.55	1.8	58.8	39.4
1986	30000	0.06	0	38.1	61.9
1987	199696	0.38	15.4	58.5	26.1
1988	389397	0.42	10.9	32.6	56.5
1989	35000	0.07	8.93	51.58	39.49
1990	30000	0.08	10.81	54.6	34.6
1991	1121675	0.62	5	58.5	35.5
1992	567377	0.57	13.9	34.7	51.4
1993	738265	0.58	15.4	50.3	34.3
1994	200000	0.43			
1995	30000	0.15			
1996	55000	0.14			
1997	144201	0.31			
1998	206824	0.33			
1999	117000	0.23			

Table 3. Harvest Rates, Total Allowable Catch, and Allocation under Variable Harvest Rate Strategy for Somass River sockeye, and 1999

Prediction Date	Somass Sockeye Run Size	Escapement into Somass R	Allowable Harvest Rate	Total Allowable Catch	Expected Sport Catch	Assessment Req'nts	Somass First Nations SFSF under interim agreement	Remaining TAC for Comm, or Native FSC
	200,000	198,500	0.8%	1,500	-	1,500	-	0
	205,000	188,500	8.0%	16,500	-	1,500	-	0
	210,000	193,500	7.9%	16,500	-	1,500	15,000	0
	220,000	200,400	8.9%	19,600	-	1,500	18,100	0
	225,000	203,350	9.6%	21,650	851	1,500	19,299	0
	250,000	218,100	12.8%	31,900	8,915	1,500	21,485	0
	275,000	232,850	15.3%	42,150	16,978	1,500	23,672	0
	300,000	247,600	17.5%	52,400	19,928	8,000	24,472	0
	325,000	262,350	19.3%	62,650	26,000	8,000	26,659	1,991
preseason	328,000	264,120	19.5%	63,880	26,240	8,001	26,921	2,718
	350,000	277,100	20.8%	72,900	28,000	8,000	28,845	8,055
	375,000	291,850	22.2%	83,150	30,000	8,000	31,032	14,118
	400,000	306,600	23.4%	93,400	32,000	8,000	32,119	21,281
	425,000	321,350	24.4%	103,650	34,000	8,000	33,222	28,428
Jun 24	450,000	336,100	25.3%	113,900	36,000	8,000	34,326	35,574
	475,000	351,000	26.1%	124,000	38,000	8,000	35,413	42,587
postseason	505,000	355,800	29.5%	149,200	40,400	8,000	38,125	62,675
Jul 22	525,000	359,000	31.6%	166,000	42,000	8,000	39,933	76,067
Jun 30	550,000	363,000	34.0%	187,000	44,000	15,000	41,439	86,561
	575,000	367,000	36.2%	208,000	46,000	15,000	43,700	103,300
	590,000	369,400	37.4%	220,600	47,200	15,001	45,055	113,344
	600,000	371,000	38.2%	229,000	48,000	15,000	45,960	120,040
	650,000	379,000	41.7%	271,000	52,000	15,001	50,480	153,519
	700,000	387,000	44.7%	313,000	56,000	15,000	55,000	187,000
	800,000	403,000	49.6%	397,000	64,000	15,000	61,422	256,578
	900,000	419,000	53.4%	481,000	72,000	15,000	65,033	328,967
	1,000,000	435,000	56.5%	565,000	80,000	15,000	68,644	401,356
	1,100,000	449,400	59.1%	650,600	88,000	15,000	72,324	475,276
	1,200,000	470,800	60.8%	729,200	90,000	15,000	75,703	548,497
	1,300,000	492,200	62.1%	807,800	90,000	15,000	79,082	623,718
	1,400,000	513,600	63.3%	886,400	90,000	15,000	82,461	698,939
	1,500,000	535,000	64.3%	965,000	90,000	15,000	85,840	774,160
	1,600,000	556,400	65.2%	1,043,600	90,000	15,000	89,219	849,381
	1,700,000	577,800	66.0%	1,122,200	90,000	15,000	92,598	924,602
	1,800,000	599,200	66.7%	1,200,800	90,000	15,000	95,977	999,823

Table 4. Summary of mean absolute percent error (MAPE) of forecasts of returns from observed returns

Return Year	Returns Observed	SSM forecast	SSM Devs (obs-4cst)	SSM Devs as % of Obs
88	850	740	110	12.94
89	460	387	73	15.87
90	354	342	12	3.39
91	1820	668	1152	63.30
92	997	1372	-375	-37.61
93	1279	1229	50	3.91
94	465	792	-327	-70.32
95	200	422	-222	-111.00
96	380	400	-20	-5.26
97	465	693	-228	-49.03
98	660	771	-111	-16.82
99	509	575	-66	-12.97
2000		1738		
MAPE				33.5
		SStM	SStM	SStM
88	850	560	290	34.12
89	460	501	-41	-8.91
90	354	479	-125	-35.31
91	1820	653	1167	64.12
92	997	1089	-92	-9.23
93	1279	996	283	22.13
94	530	464	66	12.45
95	200	264	-64	-32.00
96	380	279	101	26.58
97	465	357	108	23.23
98	660	451	209	31.67
99	509	332	177	34.77
2000		423		
MAPE				27.88
		SEPB	SEPB	SEPB
88	850	1104	-254	-29.88
89	460	790	-330	-71.74
90	354	709	-355	-100.28
91	1820	800	1020	56.04
92	997	959	38	3.81
93	1279	992	287	22.44
94	530	615	-85	-16.04
95	200	565	-365	-182.50
96	380	557	-177	-46.58
97	465	715	-250	-53.76
98	660	903	-243	-36.82
99	509	665	-156	-30.65
2000				
MAPE				54.21

Table 5. A comparison of several attributes of SStM, SSM and SEPB forecasts.

		(a) includes 91		(b) excludes 91		(c)	(d)
Forecast	MAPE	r-square	prob.	r-square	prob.	direction correct	risk rank
SStM	28%	0.46	0.02	0.78	< 0.01	9 of 11	1
SSM	34%	0.3	0.06	0.77	< 0.01	8 of 11	3
SEPB	54%	0.32	0.05	0.68	< 0.01	9 of 11	2

(a) analysis includes 12 years of predicted and observed returns

(b) excludes the 1991 return year from analysis when all forecasts failed to anticipate a record return of sockeye to Barkley Sound.

(c) number of times in past 12 years each forecast has correcty identified whether returns would increase or decrease relative to returns the previous year.

(d) year 2000 forecasts are ranked from most to least conservative based on the magnitude of the predicted return i.e. the SStM forecast is the lowest of the three in 2000 and thus is considered to be the most conservative or risk averse.

Table 6. In-season re-forecasting of Somass River sockeye returns during 1999.

Date	Forecast
Preseason	328,000
24-Jun-99	450,000
30-Jun-99	550,000
08-Jul-99	550,000
15-Jul-99	550,000
22-Jul-99	525,000
29-Jul-99	525,000
Post Season Actual	505,000

Table 7. Summary for SStM Forecasts, BkSdSk.

Stock	Smolt Year	Release (millions)	SST 03-05 (celcius)	Dev's. or Temp/ 30 year mean	Survival Pred. %	Adults Expectec	Adult production expectec by smolt year 3's	4's	5's
Great	1984	9.2				0	0	0	0
Central	1985	12.35				0	0	0	0
	1986	10.23	9.8	0.42	2.25	230175	16112	126595	80561
	1987	6.19	10.3	0.92	2.25	139275	9749	76601	48746
	1988	5.3	9.3	-0.08	5	265000	18550	145750	92750
	1989	7.1	9.27	-0.11	5	355000	24850	195250	124250
	1990	9.09	9.87	0.49	5	454500	31815	249975	159075
	1991	9.7	9.57	0.19	5	485000	33950	266750	169750
	1992	4.8	11	1.62	2.25	108000	7560	59400	37800
	1993	7.6	10.3	0.92	2.25	171000	11970	94050	59850
	1994	4.43	9.77	0.39	2.25	99675	6977	54821	34886
	1995	4.94	9.93	0.55	2.25	111150	7781	61133	38903
	1996	10.02	10.17	0.79	2.25	225450	15782	123998	78908
	1997	4.43	10.1	0.72	2.25	99675	6977	54821	34886
	1998	17.81	10.43	1.05	2.25	400725	28051	220399	140254
	1999	11.95	8.77	-0.61	5	597500	41825	328625	209125
Sproat	1984	11.72				0	0	0	0
	1985	19.56				0	0	0	0
	1986	6.97	9.8	0.42	2.25	156825	25092	98800	31365
	1987	8.3	10.3	0.92	2.25	186750	29880	117653	37350
	1988	9.3	9.3	-0.08	5	465000	74400	292950	93000
	1989	13.2	9.27	-0.11	5	660000	105600	415800	132000
	1990	10.55	9.87	0.49	5	527500	84400	332325	105500
	1991	9.16	9.57	0.19	5	458000	73280	288540	91600
	1992	5.88	11	1.62	2.25	132300	21168	83349	26460
	1993	4.6	10.3	0.92	2.25	103500	16560	65205	20700
	1994	5.99	9.77	0.39	2.25	134775	21564	84908	26955
	1995	6.77	9.93	0.55	2.25	152325	24372	95965	30465
	1996	11.7	10.17	0.79	2.25	263250	42120	165848	52650
	1997	5.87	10.1	0.72	2.25	132075	21132	83207	26415
	1998	8.46	10.43	1.05	2.25	190350	30456	119921	38070
	1999	8.23	8.77	-0.61	5	411500	65840	259245	82300
Hen.	1984	4.75				0	0	0	0
	1985	3.52				0	0	0	0
	1986	4.19	9.8	0.42	2.25	94275	0	48080	46195
	1987	2.02	10.3	0.92	2.25	45450	0	23180	22271
	1988	0.15	9.3	-0.08	5	7500	0	3825	3675
	1989	0.77	9.27	-0.11	5	38500	0	19635	18865
	1990	4.88	9.87	0.49	5	244000	0	124440	119560
	1991	1.08	9.57	0.19	5	54000	0	27540	26460
	1992	0.4	11	1.62	2.25	9000	0	4590	4410
	1993	0.7	10.3	0.92	2.25	15750	0	8033	7718
	1994	1.62	9.77	0.39	2.25	36450	0	18590	17861
	1995	5.46	9.93	0.55	2.25	122850	0	62654	60197
	1996	0.33	10.17	0.79	2.25	7425	0	3787	3638
	1997	0.05	10.1	0.72	2.25	1125	0	574	551
	1998	1.94	10.43	1.05	2.25	43650	0	22262	21389
	1999	1.01	8.77	-0.61	5	50500	0	25755	24745

Table 8. Barkley Sound Sockeye SStM Predictions by Return Year

Stock	Return Year	Adult production expected for fishery by return year			
		3's	4's	5's	Total
Great Central	1988		126596		126596
	1989	18550	76601	80561	175712
	1990	24850	145750	48746	219346
	1991	31815	195250	92750	319815
	1992	33950	249975	124250	408175
	1993	7560	266750	159075	433385
	1994	11970	59400	169750	241120
	1995	6977	94050	37800	138827
	1996	7781	54821	59650	122452
	1997	15782	61133	34886	111801
	1998	6977	123998	38903	169878
	1999	28051	54821	78908	161780
	2000	41825	220399	34886	297110
	2001		328625	140254	468879
Sproat	1988	29880	98800		128680
	1989	74400	117653	31365	223418
	1990	105600	292950	37350	435900
	1991	84400	415800	93000	593200
	1992	73280	332325	132000	537605
	1993	21168	288540	105500	415208
	1994	16560	83349	91600	191509
	1995	21564	65205	26460	113229
	1996	24372	84908	20700	129980
	1997	42120	95965	26955	165040
	1998	21132	165848	30465	217445
	1999	30456	83207	52650	166313
	2000	65840	119921	26415	212176
	2001		259245	38070	297315
Henderson	1988	0	48080		48080
	1989	0	23180	46195	69375
	1990	0	3825	22271	26096
	1991	0	19635	3675	23310
	1992	0	124440	18865	143305
	1993	0	27540	119560	147100
	1994	0	4590	26460	31050
	1995	0	8033	4410	12443
	1996	0	18590	7718	26308
	1997	0	62654	17861	80515
	1998	0	3787	60197	63984
	1999	0	574	3638	4212
	2000	0	22262	551	22813
	2001	0	25755	21389	47144

Table 9. Salinity Ob's. Amphitrite, 1972-

Smolt Release Year	Feb.	March	April	May	Mean 03-05	Ln of predicte C-surv.	% C-surv
1972	27.5	25.2	27.9	29.9	27.67	0.04	1.04
1973	28.9	29.1	30.4	30.7	30.07	2.27	9.67
1974	26.6	27.2	28.1	28.9	28.07	0.41	1.51
1975	28.3	28.6	30.1	30.7	29.80	2.02	7.55
1976	28.1	27.7	28.8	30.1	28.87	1.15	3.17
1977	29.3	28.8	29.1	30	29.30	1.56	4.74
1978	28.7	29.5	29.6	30.2	29.77	1.99	7.32
1979	28.6	28.3	30.4	30.9	29.87	2.08	8.03
1980	28.8	28.1	29.3	30.1	29.17	1.43	4.19
1981	28.5	28.6	28.8	29.4	28.93	1.22	3.37
1982	27.1	27.9	27.5	30.3	28.57	0.88	2.4
1983	28.1	26.9	28.7	29.3	28.30	0.63	1.87
1984	28.2	27.7	27.8	28.2	27.90	0.26	1.29
1985	29.7	29.8	29.5	29.3	29.53	1.77	5.89
1986	28.2	26.5	28.5	28.7	27.90	0.26	1.29
1987	27.4	27.6	29	29.9	28.83	1.12	3.07
1988	27.8	28.7	28.7	28	28.47	0.78	2.19
1989	28.9	28.6	28	30.5	29.03	1.31	3.7
1990	28.5	28.4	29.9	31.1	29.80	2.02	7.55
1991	26.8	28.6	29.3	30	29.30	1.56	4.74
1992	27	29.1	29.7	30.6	29.80	2.02	7.54
1993	28.2	29.2	27.9	28	28.37	0.69	1.99
1994	28.7	27.5	29.3	30.1	28.97	1.25	3.48
1995	26.7	27.7	29.5	31.1	29.43	1.68	5.37
1996	28.6	28.6	28.4	30.2	29.07	1.34	3.82
1997	28.8	27.8	27.3	28.2	27.77	0.13	1.14
1998	28.6	28.9	30.3	31.3	30.17	2.36	10.59
1999	28.1	28.3	30	31.1	29.80	2.02	7.54

Table 10. Summary for SSM Forecasts, BkSdSk.

Stock	Smolt Year	Release (millions)	Salinity/ Survival Pred.	Adults Expected	Adult production expected by smolt year 3's	4's	5's
Great Central	1984	9.2	1.29	118680	8308	65274	41538
	1985	12.35	5.27	650845	45559	357965	227796
	1986	10.23	1.29	131967	9238	72582	46188
	1987	6.19	3.07	190033	13302	104518	66512
	1988	5.3	2.19	116070	8125	63839	40025
	1989	7.1	3.7	262700	18389	144485	91945
	1990	9.09	7.55	686295	48041	377462	240203
	1991	9.7	4.74	459780	32185	252879	160923
	1992	4.8	7.54	361920	25334	199056	126672
	1993	7.6	1.99	151240	10587	83182	52934
	1994	4.43	3.48	154164	10791	84790	53957
	1995	4.94	5.37	265278	18569	145903	92847
	1996	10.02	3.82	382764	26793	210520	133967
	1997	4.43	1.14	50502	3535	27776	17676
	1998	17.81	10.59	1886079	132026	1037343	660128
	1999	11.95	7.54	901030	63072	495567	315361
Sproat	1984	11.72	1.29	151188	24190	95248	30238
	1985	19.56	5.27	1030812	164930	649412	206162
	1986	6.97	1.29	89913	14386	56645	17983
	1987	8.3	3.07	254810	40770	160530	50962
	1988	9.3	2.19	203670	32587	128312	40734
	1989	13.2	3.7	488400	78144	307692	97680
	1990	10.55	7.55	796525	127444	501811	159305
	1991	9.16	4.74	434184	69469	273536	86837
	1992	5.88	7.54	443352	70936	279312	88670
	1993	4.6	1.99	91540	14646	57670	18308
	1994	5.99	3.48	208452	33352	131325	41690
	1995	6.77	5.37	363549	58168	229036	72710
	1996	11.7	3.82	446940	71510	281572	89388
	1997	5.87	1.14	66918	10707	42158	13384
	1998	8.46	10.59	895914	143346	564426	179183
	1999	8.23	7.54	620542	99287	390941	124108
Hen.	1984	4.75	1.29	61275	0	31250	30025
	1985	3.52	5.27	185504	0	94607	90897
	1986	4.19	1.29	54051	0	27566	26485
	1987	2.02	3.07	62014	0	31627	30387
	1988	0.15	2.19	3285	0	1675	1610
	1989	0.77	3.7	28490	0	14530	13960
	1990	4.88	7.55	368440	0	187904	180536
	1991	1.08	4.74	51192	0	26108	25084
	1992	0.4	7.54	30160	0	15382	14778
	1993	0.7	1.99	13930	0	7104	6826
	1994	1.62	3.48	56376	0	28752	27624
	1995	5.46	5.37	293202	0	149533	143669
	1996	0.33	3.82	12606	0	6429	6177
	1997	0.05	1.14	570	0	291	279
	1998	1.94	10.59	205446	0	104777	100669
	1999	1.01	7.54	76154	0	38839	37315

Table 11. Barkley Sound Sockeye SSM Predictions by Return Year

Stock	Return Year	Adult production expected for fishery by return year			
		3's	4's	5's	Total
Great Central	1988	13302	72582	227796	313680
	1989	8125	104518	46188	158831
	1990	18389	63839	66512	148740
	1991	48041	144485	40625	233151
	1992	32185	377462	91445	501092
	1993	25334	252879	240203	518416
	1994	10587	199056	160923	370566
	1995	10791	83182	126672	220645
	1996	18569	84790	52934	156293
	1997	26793	145903	53957	226653
	1998	3535	210520	92847	306902
	1999	132026	27776	133967	293769
	2000	63072	1037343	17676	1118091
	2001		495567	660128	1155695
Sproat	1988	40770	56645	206162	303577
	1989	32587	160530	17983	211100
	1990	78144	128312	50962	257418
	1991	127444	307692	40734	475870
	1992	69469	501811	97680	668960
	1993	70936	273536	159305	503777
	1994	14646	279312	86837	380795
	1995	33352	57670	88670	179692
	1996	58168	131325	18308	207801
	1997	71510	229036	41690	342236
	1998	10707	281572	72710	364989
	1999	143346	42158	89388	274892
	2000	99287	564426	13384	677097
	2001		390941	179183	570124
Henderson	1988	0	27566	90897	118463
	1989	0	31627	26485	58112
	1990	0	1675	30387	32062
	1991	0	14530	1610	16140
	1992	0	187904	13960	201864
	1993	0	26108	180536	206644
	1994	0	15382	25084	40466
	1995	0	7104	14778	21882
	1996	0	28752	6826	35578
	1997	0	149533	27624	177157
	1998	0	6429	143669	150098
	1999	0	291	6177	6468
	2000	0	104777	279	105056
	2001	0	38839	100669	139508

Table 12. Summary for SEPB Forecasts, BkSdSk.

Stock	Smolt Year	Release (millions)	SEP Surv. Biost.	Adults Expecte	Adult production expectec by smolt year 3's	4's	5's
Great	1984	9.2	4.5	414000	28980	227700	144900
Central	1985	12.35	4.5	555750	38903	305663	194513
	1986	10.23	4.5	460350	32225	253193	161123
	1987	6.19	4.5	278550	19499	153203	97493
	1988	5.3	4.5	238500	16695	131175	83475
	1989	7.1	4.5	319500	22365	175725	111825
	1990	9.09	4.5	409050	28634	224978	143168
	1991	9.7	4.5	436500	30555	240075	152775
	1992	4.8	4.5	216000	15120	118800	75600
	1993	7.6	4.5	342000	23940	188100	119700
	1994	4.43	4.5	199350	13955	109643	69773
	1995	4.94	4.5	222300	15561	122265	77805
	1996	10.02	4.5	450900	31563	247995	157815
	1997	4.43	4.5	199350	13955	109643	69773
	1998	17.81	4.5	801450	56102	440798	280508
	1999	11.95	4.5	537750	37643	295763	188213
Sproat	1984	11.72	4.5	527400	84384	332262	105480
	1985	19.56	4.5	880200	140832	554526	176040
	1986	6.97	4.5	313650	50184	197600	62730
	1987	8.3	4.5	373500	59760	235305	74700
	1988	9.3	4.5	418500	66960	263655	83700
	1989	13.2	4.5	594000	95040	374220	118800
	1990	10.55	4.5	474750	75960	299093	94950
	1991	9.16	4.5	412200	65952	259686	82440
	1992	5.88	4.5	264600	42336	166698	52920
	1993	4.6	4.5	207000	33120	130410	41400
	1994	5.99	4.5	269550	43128	169817	53910
	1995	6.77	4.5	304650	48744	191930	60930
	1996	11.7	4.5	526500	84240	331695	105300
	1997	5.87	4.5	264150	42264	166415	52830
	1998	8.46	4.5	380700	60912	239841	76140
	1999	8.23	4.5	370350	59256	233321	74070
Hen.	1984	4.75	4.5	213750	0	109013	104738
	1985	3.52	4.5	158400	0	80784	77616
	1986	4.19	4.5	188550	0	96161	92390
	1987	2.02	4.5	90900	0	46359	44541
	1988	0.15	4.5	6750	0	3443	3308
	1989	0.77	4.5	34650	0	17672	16979
	1990	4.88	4.5	219600	0	111996	107604
	1991	1.08	4.5	48600	0	24786	23814
	1992	0.4	4.5	18000	0	9180	8820
	1993	0.7	4.5	31500	0	16065	15435
	1994	1.62	4.5	72900	0	37179	35721
	1995	5.46	4.5	245700	0	125307	120393
	1996	0.33	4.5	14850	0	7574	7277
	1997	0.05	4.5	2250	0	1148	1103
	1998	1.94	4.5	87300	0	44523	42777
	1999	1.01	4.5	45450	0	23180	22271

Table 13. Barkley Sd. Sockeye SEPB Predictions by Return Year

Stock	Return Year	Adult production expected for fishery by return year			
		3's	4's	5's	Total
Great Central	1988	19499	253193	194513	467205
	1989	16695	153203	161123	331021
	1990	22365	131175	97493	251033
	1991	28634	175725	83475	287834
	1992	30555	224978	111825	367358
	1993	15120	240075	143168	398363
	1994	23940	118800	152775	295515
	1995	13955	188100	75600	277655
	1996	15561	109643	119700	244904
	1997	31563	122265	69773	223601
	1998	13955	247995	77805	339755
	1999	56102	109643	157815	323560
	2000	37643	440798	69773	548214
Sproat	1988	59760	197600	176040	433400
	1989	66960	235305	62730	364995
	1990	95040	263655	74700	433395
	1991	75960	374220	83700	533880
	1992	65952	299093	118800	483845
	1993	42336	259686	94950	396972
	1994	33120	166698	82440	282258
	1995	43128	130410	52920	226458
	1996	48744	169817	41400	259961
	1997	84240	191930	53910	330080
	1998	42264	331695	60930	434889
	1999	60912	166415	105300	332627
	2000	59256	239841	52830	351927
Henderson	1988	0	96161	77616	173777
	1989	0	46359	92390	138749
	1990	0	3443	44541	47984
	1991	0	17672	3308	20980
	1992	0	111996	16979	128975
	1993	0	24786	107604	132390
	1994	0	9180	23814	32994
	1995	0	16065	8820	24885
	1996	0	37179	15435	52614
	1997	0	125307	35721	161028
	1998	0	7574	120393	127967
	1999	0	1148	7277	8425
	2000	0	44523	1103	45626

Table 14. Barkley Sound sockeye year 2000 return forecasts.

	Probability of Achieving Specified Run Sizes*			
Forecast	25%	50%	75%	90%
SStM	714,000	532,000	485,000	362,000
SSM	2,146,000	1,900,000	1,185,000	564,000
SEPB	982,000	946,000	437,000	NA < 0

* probability that the actual run size will exceed the specified forecast.

Table 15. Barkley Sound sockeye stock and Robertson Creek coho marine survival deviations from 1974 -1999.

Return year	Total stock	Deviations from 24 year mean of total	Coho Brood Year	Coho Rtrn. Year	Sox Rtrn. Year	Rob. Ck* Coho Csrv (as %)	Devs from 23 year Csrv mean
1974	321315	-479985	1972	1975	1976	6.6	2.252
1975	420826	-380474	1973	1976	1977	7.7	3.352
1976	880540	79240	1974	1977	1978	7.2	2.852
1977	1399011	597711	1975	1978	1979	4.9	0.552
1978	344000	-457300	1976	1979	1980	8.8	4.452
1979	1088166	286866	1977	1980	1981	4.6	0.252
1980	961536	160236	1978	1981	1982	2.2	-2.148
1981	1349191	547891	1979	1982	1983	2	-2.348
1982	880261	78961	1980	1983	1984	5.7	1.352
1983	1504987	703687	1981	1984	1985	6.9	2.552
1984	1172004	370704	1982	1985	1986	2	-2.348
1985	669070	-132230	1983	1986	1987	3.9	-0.448
1986	300000	-501300	1984	1987	1988	2.9	-1.448
1987	635665	-165635	1985	1988	1989	1.8	-2.548
1988	849662	48362	1986	1989	1990	4.9	0.552
1989	460401	-340899	1987	1990	1991	9	4.652
1990	353910	-447390	1988	1991	1992	5.9	1.552
1991	1820145	1018845	1989	1992	1993	4.6	0.252
1992	996793	195493	1990	1993	1994	2.4	-1.948
1993	1279074	477774	1991	1994	1995	0.1	-4.248
1994	500000	-301300	1992	1995	1996	1.3	-3.048
1995	199293	-602007	1993	1996	1997	1.6	-2.748
1996	380123	-421177	1994	1997	1998	3	-1.348
1997	465237	-336063	1995	1998	1999	3.6	-0.748
1998	659745	-141555	1996	1999	2000	2.1	-2.248
1999	509353	-291947	1997	2000	2001		
2000			1998	2001	2002		
Mean	801300					4.3478261	

* Data from Kadowaki & Holtby (1998). S98-5, Appendix Table 1.

Table 16. Relationships between deviations from average marine survival rates of coho in year n and deviations from average returns of sockeye (SRD's) in year n+1 for the 1984-1995 (CLI_{12}) and 1972-1995 (CLI_{24}) brood years.

		n	r^2	prob.	sockeye returns In 2000
CLI_{12}	$(SRD's + 10^6)/ 10^6 = (0.163 \text{ coho survival deviations} + 10) - 0.577$	12	0.74	< 0.01	490,648
CLI_{24}	$(SRD's + 10^6)/ 10^6 = (0.09 \text{ coho survival deviations} + 10) + 0.113$	24	0.27	< 0.05	611,800

* assumes 1996 brood year coho survived at 2.1 %

Figure 1. Location of Barkley Sound and Statistical Area 23 on the west coast of Vancouver Island. Cellular divisions numbered 23.1-23.10 indicate the ten statistical subareas in which openings and closures are used to control fisheries for sockeye.

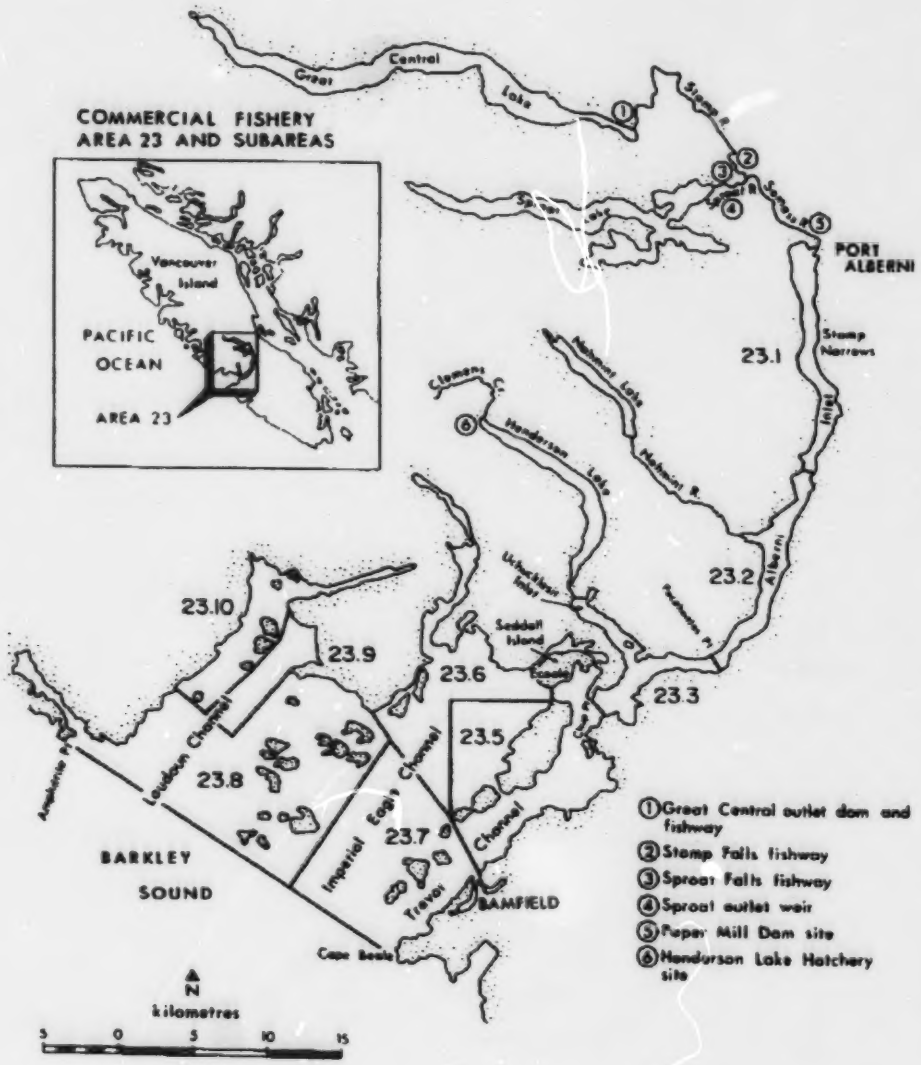

Figure 2. Sockeye Returns to Barkley Sound 1974-1999